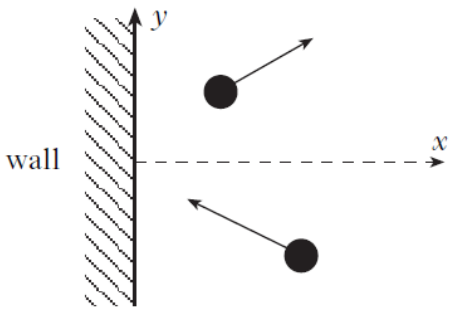
Impulse

2005

A4. A ball of mass 0·01 kg collides with a fixed vertical wall. Immediately before the collision the velocity of the ball is $-3\mathbf{i} + 4\mathbf{j}$, and just after the collision the velocity is $2\mathbf{i} + 3\mathbf{j}$, where $\mathbf{i}$ and $\mathbf{j}$ are unit vectors in the x and y directions of the rectangular coordinate system shown below and speeds are measured in m s^{-1}.



Calculate the magnitude of the impulse exerted on the ball by the wall. **3**

2009

A6. Football players Ali, Billy and Carrie each stand on a different vertex of an equilateral triangle. Ali passes a football of mass m kg which reaches Billy with speed U m s^{-1}. Billy diverts the ball to Carrie with speed U m s^{-1}. Assume that the ball travels between players along the ground in a straight line.

Find an expression, in terms of m and U, for the magnitude of the impulse given to the ball by Billy. **5**

2010

A5. A catapult exerts a force $F(t) = 100\cos\frac{1}{2}\pi t$ newtons on a stone for $0 \le t \le 1$, where t seconds is the time that the stone is in contact with the catapult.

Calculate the change in momentum of the stone. **3**

2013

A2. A ball of mass 0·5 kg is released from rest at a height of 10 metres above the ground.

If the ball reaches 2·5 metres after its first bounce, calculate the size of the impulse exerted by the ground on the ball. **4**

2014

A1. Two particles, P and Q, of masses 2 kg and m kg respectively, initially lie at rest in a straight line on a smooth horizontal surface. Particle P is acted on by a constant force of 3 N for 4 seconds, causing it to accelerate towards Q. When P collides with Q the particles coalesce and begin to move with speed $3{\cdot}75\ \text{m s}^{-1}$.

Find the value of m, the mass of particle Q. **4**

2016

1. A bicycle and rider have a total mass of 70 kg. They are travelling at $12\ \text{m s}^{-1}$. The cyclist applies the brakes for 1·5 seconds, resulting in a total resistive force of 180 newtons.

What is the speed of the bicycle after 1·5 seconds? **3**

Conservation of Momentum

2011

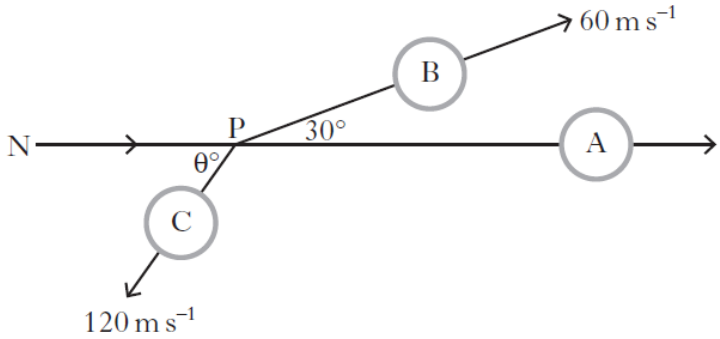
A1. A smooth horizontal surface contains the perpendicular unit vectors **i** and **j**. A body of mass 1 kg has velocity $-2\mathbf{i} + 4\mathbf{j}$ m s^{-1} and collides with a second body of mass 2 kg moving in the plane.

The bodies coalesce and move with velocity $\mathbf{i} + 4\mathbf{j}$ m s^{-1}.

Calculate the speed of the larger mass before the collision. **3**

2015

A1. A shell of mass 20 kg is travelling in a horizontal plane along the line NP at 100 m s^{-1}. At P it breaks into 3 pieces A, B and C of masses 12 kg, 6 kg and 2 kg respectively. These pieces instantaneously travel as shown in the diagram.



Find the speed of A, and the size of angle θ°. **4**

2016 SP

1. A curling stone, P, of mass 18 kg is moving with velocity $\begin{pmatrix} 0 \\ -1{\cdot}1 \end{pmatrix}$ m s^{-1} relative to a suitable set of coordinate axes. It collides with a stationary curling stone, Q, of mass 20 kg. Q then moves off with velocity $\begin{pmatrix} 0{\cdot}36 \\ -0{\cdot}72 \end{pmatrix}$ m s^{-1}.

Calculate the speed with which P travels immediately after impact. **3**

2005 SP

4. In vehicle safety trials, a car of mass 1200 kilograms and a van of mass 2000 kilograms were made to crash into each other on a skid-pan. The two vehicles locked together and moved on as one combined mass.

Before impact, taking the x-axis as the direction of motion of the car, the velocity of the car was $18\mathbf{i}$ m s^{-1} and the velocity of the van was $(5\mathbf{i} + 12\mathbf{j})$ m s^{-1}, where **i**, **j** are the unit vectors in the directions of the rectangular axes Ox and Oy respectively.

Given that friction can be ignored, calculate the speed and direction of the combined mass immediately after the crash. **5**

2007

A3. Two small spheres A and B have masses $3m$ kg and $2m$ kg respectively. They are moving towards each other, from opposite directions, in a straight line on a smooth horizontal surface. Each sphere has speed U m s^{-1} when they collide head on. After the collision, the direction of motion of B is reversed but its speed is unchanged.

Show that the direction of motion of A is also reversed and find its speed in terms of U. **3**